DOCUMENT RESUME

ED 263 390 CE 042 908

TITLE Industrial Arts Curriculum Guide for Automated Machining in Metals Technology.
SPONS AGENCY Connecticut State Dept. of Education, Hartford. Div. of Vocational, Technical, and Adult Education.
PUB DATE May 85
NOTE 61p.; Booklet prepared by the Connecticut Industrial Arts Association.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Computer Oriented Programs; *Course Content; *Industrial Arts; *Machine Tools; Machinists; Metal Industry; *Metal Working; *Numerical Control; Patternmaking; Safety; Secondary Education; State Curriculum Guides; Tool and Die Makers
IDENTIFIERS *Automated Machining

ABSTRACT

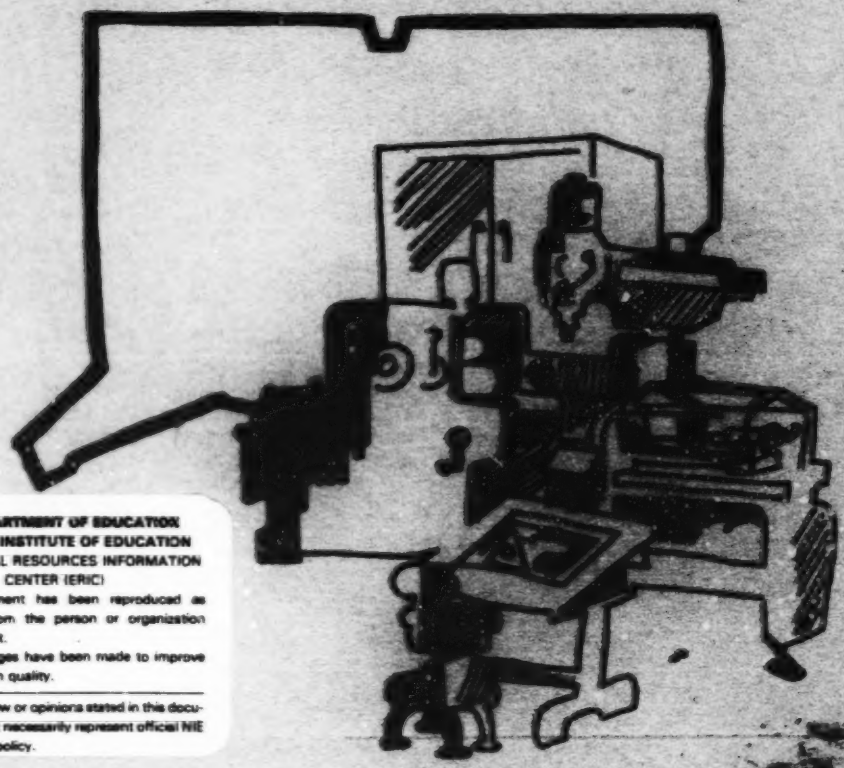
This curriculum guide is designed to be used for creating programs in automated machining education in Connecticut. The first sections of the guide are introductory, explaining the importance of computer-numerically controlled machines, describing the industrial arts scope and sequence for kindergarten through adult levels, describing the provisions of Public Law 94-142 (Education for All Handicapped Act), and the general objectives and prerequisite skills needed for automated machine operators. The guide then provides course outlines for numerical control machining, computerized numerical control (CNC) machining, the CNC lathe, and CNC milling. The guide also introduces the concept of computer-assisted manufacturing and provides safety guidelines for metalworking. A glossary and list of suggested text and reference books complete the guide. (KC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

CT851330Y

ED263390

ED042908



U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

Industrial Arts Curriculum Guide

Connecticut State Department of Education
Division of Vocational, Technical
And Adult Education

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

V Richards

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

AUTOMATED MACHINING IN METALS TECHNOLOGY

2

INDUSTRIAL ARTS CURRICULUM GUIDE

FOR

AUTOMATED MACHINING

IN

METALS TECHNOLOGY

Prepared for

State Department of Education
Division of Vocational, Technical and Adult Education

Prepared by

Connecticut Industrial Arts Association

All opinions expressed reflect the views of the
authors and are not necessarily those of
the State Department of Education.

May, 1985

TABLE OF CONTENTS

Disclaimer 1

Committee Members 2

State Board of Education 3

Introduction 4

Industrial Arts Scope and Sequence 6

Public Law 94-142 (Education for All Handicapped) . . . 14

General Objectives 18

Size Description Dimensioning for NC & CNC 19

Curriculum - Numerical Control Machining 22

Curriculum - Computerized Numerical Control Machining . . 26

Curriculum - Computerized Numerical Control Lathe . . . 31

Curriculum - Computerized Numerical Control Milling . . 38

Introduction - CAM 42

Metalworking Safety Guide 45

Glossary 50

Suggested Text and Reference Books 55

DISCLAIMER

The activity which is the subject of this report was supported in whole or in part by the U. S. Department of Education. However, the opinions expressed herein do not necessarily reflect the position or policy of the U.S. Department of Education, and no official endorsement by the U.S. Department of Education should be inferred.

[20 U.S.C. 122 1c (b) (1)]

CONNECTICUT INDUSTRIAL ARTS CURRICULUM COMMITTEE

FOR

AUTOMATED MACHINING

IN

METALS TECHNOLOGY

Allan J. Bradanini, chairperson
North Haven High School
North Haven, CT

Martin W. Graff
Wethersfield High School
Wethersfield, CT

Carroll Hersom
Stonington High School
Stonington, CT

Robert H. Lee
Killingly High School
Danielson, CT

Stephen Salisbury
New London High School
New London, CT

Joseph B. Witkin
Portland High School
Portland, CT

David M. Mordavsky
Industrial Arts Consultant
State Department of Education
Hartford, CT

CONTRIBUTORS

Nick Iannone
North Haven High School
North Haven, CT

Roland R. Johnson, Jr.
Regional Manager
Paxton Patterson Co.
Clifton, NJ

Reggie Mohan
MAHO Co.
Naugatuck Industrial Park
Naugatuck, CT

Bill Condon
Robert E. Morris Co.
Farmington, CT

CONNECTICUT STATE BOARD OF EDUCATION

A. Walter Esdaile

Warren J. Foley

Abraham Glassman

Dorothy C. Goodwin

Rita L. Hendel

John F. Mannix

Julia S. Rankin

James J. Szerejko

Gerald N. Tirozzi, Secretary and Commissioner of Education

Norma Foreman Glasgow, Commissioner of Higher Education (ex-officio)

Division of Vocational, Technical and Adult Education
Angelo J. Tedesco, Associate Commissioner
Bureau of Vocational Services
Errol J. Terrell, Chief

INTRODUCTION

We are living in the age of high technology. This technology has brought us the computer, which has become a major part of the educational system of Connecticut. Computers are the mainstream in many Mathematics, Business, Science and Industrial Arts programs.

The Machine Trades have used the computer to automate machining. Through the use of automation, productivity has greatly improved as well as the ability to perform job specifications more accurately and consistently.

Automated machining began many years ago with the introduction of tracer lathes. The operator of the tracer lathe followed a pattern, which was attached to the lathe to produce the product. Following the development of the tracer lathe, Mr. John Pearson and the M.I.T. developed in 1952, on behalf of the U.S. Air Force, the first numerically controlled (NC) machine tool for the production of particularly complicated workpieces. Some fifteen years ago NC machines were extremely costly and only very few companies had the courage and the conviction to invest in this new technology. The main reason for the sudden increase was certainly the development of the microprocessors. The use of NC machines in this way was first attractive to large, medium and small manufacturing companies. Today the cost of, for example, a control unit

with much larger capacity will only cost a twenty-fifth as much as compared to 1968. The initial mistrust as to the reliability of electrical control has meanwhile disappeared.

With the advance of the computer, a person no longer has to punch cards or tapes. The information can be entered directly into the computer which can store the information in a number of ways, generate the program, interpret the information, and operate the machine tool. This system is now called Computerized Numerical Control or CNC.

In nearly all manufacturing companies there is high demand for NC and CNC trained personnel and this demand will sharply increase in the future. Therefore, training is of the utmost importance, and it is our responsibility in education to see that the students have this opportunity.

INDUSTRIAL ARTS SCOPE AND SEQUENCE

Industrial Arts learning experiences are sequential, beginning in the lowest grades and continuing through adult and higher education. As an integral part of the total educational program, Industrial Arts is designed to meet student's needs as they relate to a modern technological society. Through manipulative and research experiences, with a variety of tools, machines, processes and products of industry, students develop an awareness of how industry and its many components function.

A comprehensive Industrial Arts program will provide for a sequence of courses in industrial areas. These include, but are not limited to:

Drafting
Electricity/Electronics
General Laboratory
Graphic Arts
Industrial Ceramics
Metal Technology
Plastic Technology
Power Technology
Wood Technology

The objectives of Industrial Arts are:

.... To develop an insight and understanding of industry, its place in our society, and the free enterprise system.

.... To develop problem solving skills related to the materials, tools, processes and products of industry.

.... To provide for a degree of skill development through a series of sequential courses in common industrial areas with vocational emphasis at the advanced levels.

.... To develop knowledge of the tools, machines, materials and processes of industry through their practical and safe use.

.... To develop an appreciation of good design and craftsmanship.

.... To develop an understanding of industrial and technological career opportunities and their requirements.

.... To develop those traits which will help students obtain and maintain employment.

.... To develop consumerism regarding the goods and services of industry.

.... To discover avocational and recreational interests.

.... To understand the affects of industry and civilization upon the environment.

The following sequential phases represent a range of Industrial Arts activities from kindergarten through adulthood. Reference is made to grade level to assist local education agencies (LEA's) in planning. It is understood that a wide variety of grade organizations are employed based upon local situations.

I. Self-Awareness (grades K-6)

Industrial Arts at this level is designed to familiarize students with the many kinds of work people do and the tools and materials they use. It is at the elementary level that Industrial Arts activities are used to enhance basic skills and understanding in all curricular areas by providing relevant hands-on experiences.

II. Industrial Arts Exploration (grades 7 & 8)

Industrial Arts at the middle school/junior high school level is designed to foster the development of a strong foundation in the concepts, skills, knowledge and attitudes regarding not only the technical but also the related and social aspects of general education.

Industrial Arts experiences at this level are exploratory in nature. The program provides students with the opportunity to develop a better understanding of their interests, abilities and aspirations. Consumer knowledge as it relates to industrial products and processes is an inherent part of these activities. A broad exploratory Industrial Arts program at the middle school/junior high school level allows individual student's interests to become more discernible for concentration at the senior high level.

III. Industrial Arts Occupational Orientation (grade 9 & 10)

Industrial Arts at this level emphasizes occupational orientation. It is here that the transition from middle school/junior high school exploratory experiences to specialization at the upper levels is made. Students may explore in greater depth a wider variety of areas, evaluate their performance, aptitudes and interests and begin to formulate career plans.

IV. Industrial Arts Specialization (grades 11 & 12)

At this level students are provided the opportunity to specialize in one or more occupational areas and to develop pre-vocational skills. Training at this level should prepare students to maximize their career options after high school.

This level should also assist individuals in making informed and meaningful occupational choices and/or prepare them for entry into advanced trade and industrial or technical education programs.

V. Adult, continuing and higher education Industrial Arts programs are designed for adults and out of school youth. These programs are avocational, pre-vocational or vocational in nature depending upon the needs of the individual and the demands of society.

Specific Guidelines for Industrial Arts

Grade Level

7 - 12 and Adult

Selection of Students

Open to all students who can profit from instruction, and work safely in a Lab/Shop situation.

Length of Program

Level One (Exploratory) grades seven (7) and eight (8) - Lab/Shop classes meet a minimum of 60 hours per year. Lab/Shop periods must be of at least 40 continuous minutes and should not exceed 60 minutes.

Level Two (Occupational Orientation) grades nine (9) through twelve (12), or grades ten (10) through twelve (12) - students electing Level Two Industrial Arts courses must have the opportunity to participate in a minimum of 225 minutes of Lab/Shop activities per week, per semester. Daily Lab/Shop periods must be of at least 45 continuous minutes and should not exceed 60 minutes.

Level Three and Four (Specialization and Pre-Vocational) grades eleven (11) and twelve (12). Students that elect Level III & IV Industrial Arts courses must have a minimum of 450 minutes per week, per year of Lab/Shop activities. Daily Lab/Shop periods must be of at least 90 continuous minutes.

The definition of a year is a minimum of 180-day school days. A semester is 90 continuous school days.

Pre-Requisites

Successful completion of Level Two course prior to participating in Level Three. Successful completion of Level Three course prior to Level Four.

Enrollments

Based on Lab/Shop size and facilities, 16 students per class maximum in Lab/Shop areas and 20 students per class in drafting. The recommended and minimum square footages are as follows:

Shop/Lab

	Recommended		Minimum	
Jr. & Sr. High School	s.f./pupil station	Net total s.f. area	s.f./pupil station	Net total s.f. area
Drafting (including storage)	48 s.f.	1000 s.f.	40 s.f.	1000 s.f.
I.A. Jr. H.S. Level One (including storage)	100 s.f.	2500 s.f.	82 s.f.	2050 s.f.
I.A. Sr. H.S. Levels Two, Three & Four (including storage)	144 s.f.	3600 s.f.	120 s.f.	3000 s.f.

A classroom should be made available for related study, adjacent to the Shop/Lab areas. All facilities must comply with OSHA regulations.

Teachers Schedule

Industrial Arts contact hours for a full-time instructor should comprise 70% to 80% of their school week, and 20% to 30% of their time in industrial arts related non-teaching duties, such as maintenance and preparation of I.A. materials.

Equipment

All equipment must be in safe operating condition and conform to all federal, state, and local standards. Equipment must be:

A. Applicable to the level being taught, i.e., size, capacity, quantity, and necessity.

B. Enhance the program level and be similar to that found in industry.

C. Take into consideration: occupational education, consumer competency, leisure time activity, and environmental awareness.

Evaluation

Continuous evaluation by students, teachers, school, vocational, advisory committee, and state. Evaluation results must become an integral part of program development and improvement.

School Credit

Equal to other academic credit granted for similar periods of time and activities.

Youth Organizations

It is recommended that the American Industrial Arts Student Association (AIASA) be an integral part of the curriculum.

Teacher Certification

Instructors shall meet the minimum standards for Industrial Arts teachers provisional certification as outlined in the "Rules and Regulations Concerning State Teacher Certification" Section 10-146-21 and Section 10-146-22.

Standard certification requires three (3) years of teaching under a provisional certificate, the last two (2) years consecutive and a master's degree or thirty (30) semester hours, consisting of a planned program at an approved institution of higher learning and an individual program, mutually determined and approved by teacher and supervising agent.

Teachers of Industrial Arts to be funded through the Vocational Education Acts must comply with Section 10-146-22 above, have one (1) year of appropriate occupational experience and complete Principles of Vocational Education, a three (3) semester hour Vocational-Technical Education course.

Sex Stereotyping

Existing activities and future plans must show evidence of actions directed toward the elimination of sex stereotyping, including continual effort to attract females to elective industrial arts courses traditionally chosen by males. Industrial arts courses which are required for any students at a particular level must be required of all students, male and female.

PUBLIC LAW 94-142

"THE EDUCATION FOR ALL HANDICAPPED CHILDREN ACT"

This law requires that all handicapped children requiring special education have available a free and appropriate public education in the least restrictive environment. The law establishes guidelines for meeting this goal. Following is some terminology the instructor should be familiar with.

Special Education is specially designed instruction at no cost to parents. It must meet unique needs of handicapped children and be provided with a written individualized education program (IEP).

An **Individualized Education Program** is a written document by parents and teachers for a handicapped child before he receives special education. The IEP is produced by a planning and placement team (PPT) meeting. The IEP reviews the present educational performance of the child, goals and objectives for the child, and specific services to be provided by the school.

A **Planning and Placement Team** is a legally established group developing or reviewing the IEP for a handicapped child. It is composed to teachers and the child's parent(s) to review information regarding the student in response to a referral for special education evaluation or to conduct an annual review.

Handicapped means:

(a) A person who is:

1. Mentally retarded
2. Hard of hearing
3. Deaf
4. Speech impaired
5. Visually handicapped
6. Seriously emotionally disturbed
7. Orthopedically impaired
8. Other health impaired person, or persons with specific learning disabilities.

(b) Who, by reason of the above;

1. Requires special education and related services
2. Cannot succeed in the regular vocational education program without special educational assistance
3. Requires a modified vocational education program (Federal Register, Vol. 42, No. 191, Oct. 3, 1977, p53864)

Disadvantaged means:

(a) Persons (other than handicapped persons) who;

1. Have academic or economic disadvantages
2. Require special services, assistance, or programs in order to enable them to succeed in vocational education programs.

(b) **Academic Disadvantage:** For the purposes of this definition of disadvantaged, means that a person;

1. Lacks reading and writing skills
2. Lacks mathematical skills
3. Performs below grade level

(c) **Economic Disadvantage:** For the purposes of this definition of disadvantaged, means;

1. Family income is at or below national poverty level
2. Participant or parent(s) of participant is recipient of public assistance
3. Participant or parent(s) or guardian of the participant is unemployed
4. Participant is institutionalized or under State guardianship

(Federal Register. Vol. 42, No. 191, Oct. 3, 1977, p52864)

Mainstreaming: Though this term does not occur in P.L. 94-142, it is a coined term thought to mean placing all handicapped learners into regular classrooms. This is not the intent of the law. Rather, handicapped learners should be placed in the least restrictive environment.

Least Restrictive Environment: Public schools must assure that, to the maximum extent appropriate, handicapped students are to be educated with non-handicapped students. Separate classes should occur only when the severity of the handicap is such that education in the regular classroom with supplementary aids cannot be accomplished adequately. If

a handicapped student is disruptive to the extent of interfering with the learning of other students in a classroom, this placement would be considered inappropriate. Thus a shop, home economics class, business class, may be inappropriate for some handicapped learners.

Role of the **Special Needs Teacher:** The special needs teacher should be supportive to the extent of helping the regular teacher identify specific characteristics and needs of every special needs student. He should help, when needed, in teaching special needs students in the classroom. Needs and placement should be jointly determined by the regular and special needs teacher.

GENERAL OBJECTIVES

I. The student will learn and follow safe procedures as practiced in industrial organization and apply them in the industrial arts laboratory situation.

II. The student will learn and practice shop personnel organization and safe interaction with others.

III. The student will learn about types, forms, shapes, and composition of metals and apply that knowledge to the proper selection of materials for their individual projects.

IV. The student will learn about drawing, planning, and the reading and interpretation of blueprints as used in the shop situation and will apply skills to produce their own drawings and plans.

V. The student will learn the use of measuring tools and instruments and apply such use in their individual work and in class work.

VI. The student will learn the proper and safe use of metal cutting tools and demonstrate their use.

VII. The student will learn the principles of Numerical Control machining and how they apply to the Lathe and Milling machines.

VIII. The student will learn the use of computers and their application in Computerized Numerical Control machining.

IX. The student will learn about a variety of vocational fields so they can maximize their career options in the future.

SIZE DESCRIPTION

DIMENSIONING FOR NC & CNC

As a prerequisite to the study of Automated Machining the student must have a basic understanding of Blueprint Reading as well as Machining techniques. The development of prints has changed since the introduction of NC & CNC machining. In addition to a complete shape description of an object, a drawing or print must also give a complete size description. that is, it must be dimensioned. The need for interchangeability of parts is the basis for the development of modern methods of size description. Drawing today must be dimensional so that workmen in widely separated places can make mating parts that will fit properly when brought together for final assembly.

The increasing need for precision manufacturing and the necessity to control size for interchangeability has shifted responsibility for size control from the machinist to the designing engineer and the draftsman.

The drawing should show the object in its completed condition, and should contain all necessary information to bring it to that final state. Therefore, in dimensioning a drawing, the designer and draftsman should keep in mind the finished piece, the shop processes required, and above all the function of the part in assembly. Whenever possible, dimensions

should be given that are convenient for the shop worker, production engineer or the programmer. The dimension should be given so that it will not be necessary to calculate, scale, or assume any figures. Dimensions should not be duplicated or superfluous.

Drawings should be made to scale and the scale should be indicated in the title block. Dimensions are given in the form of linear distances, angles, or notes and the dimensioning unit can be millimeters or the decimal inch system. Dimension placement can be either unidirectional or aligned, however, the unidirectional system is preferred. The use of datum features and surfaces is becoming common practice in industry, especially for mass-produced parts.

In the early days of NC and CNC the use of incremental or absolute control was a hot and often emotional issue. There was an almost universal belief that absolute was inherently superior to incremental. Experience, however, showed that in some instances incremental had a distinct advantage and the process of dimensioning all drawings to facilitate absolute programming could be a problem of considerable magnitude. With the use of today's control units, it is possible to incorporate both absolute and incremental in the same program by using nothing more than the appropriate addum code. It is, therefore, most important for the draftsman, engineer, programmer, and operator to understand the difference between the two systems. Some forethought and planning can contribute substantially to programming ease, and machine operation including setup.

It should also be made clear that all rules and practices of good basic dimensioning are compatible with the requirements of NC and CNC equipment. To make the best use of this type of production, the designer, draftsman, or programmer should consider the following:

1. A set of three mutually perpendicular datum or reference planes is usually required for coordinate dimensioning. These planes either must be obvious or clearly identified.
2. The designer selects as origins for dimensions, those surfaces or other features most important to the functioning of the part. Enough of these features are selected to position the part in relation to the set of mutually perpendicular planes. All related dimensions on the part are then made from these planes.
3. All dimensions should be in decimals.
4. Angles should be given, where possible, in degrees and decimal parts of degrees.
5. Standard tools. such as drills, reamers, and taps, should be determined by the design requirements of the part, not by the capability of the manufacturing machine.

INTRODUCTION

NUMERICAL CONTROL MACHINING

Numerical control is the operation of a machine by electrical devices that get their instructions from numbers. These numbers are actually instructions in the form of codes, that refer to a specific distance, position, motion or function that the machine tool must perform to machine a part.

Numerically controlled machine tools and manually controlled machine tools make the same motions and remove metal at the same rate when machining the same part. The difference is that the success of the operation no longer depends upon the skill of the operator. The success of the numerical control method depends upon holes in the tape that actuate the electrical circuits which control the movement of the machine. A proven tape will machine the work piece one time or a thousand times holding accuracy consistently without hesitation, the limiting factors being tool wear, material inconsistencies and temperature variations.

In writing this unit we realize that the microprocessor has forced many improvements on modern machine tools and due to this fact many older tape punched machines may find their way into the typical school metalworking center. Because of this we feel that it is important that the metalworking student should have some knowledge of the basic fundamentals of punched tape numerical controlled machining.

This new technology is readily adaptable to the operation of many metalworking machines or processes.

CURRICULUM NUMERICAL CONTROLLED MACHINING

I. Kinds of NC
   A. Point to Point
   B. Continuous Path Contouring

II. NC Measurements
   A. Rectangular Coordinates
      1. X, Y, and Z axis
   B. Polar Coordinates

III. Machine Axis (designation and movement)
   A. Two
   B. Three

IV. Dimensioning
   A. Incremental
   B. Absolute

V. NC Punched Tape Coding
   A. EIA Standard
      1. Characters
         a. Numbers
         b. Letters
         c. Symbols
   B. ASCII Coding

VI. Programming

A. Binary Numbers

B. Machine Codes

1. Preparatory

a. Motion

b. Specific machine cycle

c. Linear or circular

2. Miscellaneous

a. Start and stop spindle

b. Start and stop auxiliary equipment

3. Spindle speeds

4. Tool numbers

C. Machining Sequence

1. Parts program

a. Coordinate dimensions

b. Positioning

(1) Point to point

(2) Continuous path

VII. Making a Tape

A. Keyboard

B. Punch Machine

VIII. Machine Set-up

A. Review and Testing the Tape

1. Position work piece

B. Tooling

1. Tool selection and identification

2. Tool compensation

C. Fixtures

1. Clamping

2. Chucks

D. Inspection

1. Tolerances

IX. Machine operation

A. Safety

B. Operation

1. Observation

2. Tool changes

C. Cleaning and Maintenance

1. Lubrication

2. Adjustments

X. Machine Tools in Industry

A. Lathes

B. Milling Machines

C. Others

XI. Career and Vocational Guidance

A. Technical Schools

B. On the Job Training

INTRODUCTION

COMPUTERIZED NUMERICAL CONTROL MACHINING

There is no greater evolutionary aspect of numerical control than that of the control unit. Control units have progressed from bulky tube types of the 1950's to the microprocessor-based computerized numerical control (CNC) units of today.

The CNC units, actually, evolved from the Direct Numerical Control (DNC) applications of the late 1960's and early 1970's. The DNC systems were capable of controlling a large number of machine tools. They had the ability to edit tape at the machine site and collectively control production and machine tool status. With the DNC system the tape reader is bypassed. If the computer went down, the machine could still operate via tape input, DNC has taken some of the abilities of the computer and applied them to a single numerical control machine.

The computer, through the evolution of Numerical Control and DNC, makes it possible to create versatile systems, capable of producing different parts and automatically adapting to different mixes and variations of part types and lot sizes. In addition, the computer can sense the operating conditions of various machines through CNC feedback and initiate corrective action if needed.

CNC machines fit well into a manufacturing system's concept as they are primarily used in the mid-volume production range and are capable of many operating tasks in a Computer Aided Manufacturing environment. For our purposes we have only included the lathe and milling machines.

Current and future developments for CNC revolve around computer software. Computer software traditionally lags computer hardware by several years. Computer technology has accelerated so rapidly that software has fallen even further behind. It will take some time for factory management systems to be developed, from a software point of view, that will take full advantage of the increased computer capability.

CURRICULUM

INTRODUCTION TO THE LATHE

I. The Lathe

- A. Basic Principles
- B. Sizes and Types
- C. Parts of Lathe
- D. Lathe Controls
- E. Speed Changes and Adjustments
- F. Lathe Safety and Maintenance

II. Cutting Tools

- A. Cutting Tool Shapes
- B. Cutting Tool Materials
  1. High speed steel
  2. Carbide cutting tools
- C. Cutting Tool Types
  1. Roughing tools
  2. Finishing tools
  3. Facing tools
  4. Parting tools
  5. Round nose tools

III. Cutting the Metal

A. Types of Cuts

1. Rough cuts

2. Finishing cuts

B. Cutting Speeds and Feeds

1. Charts and references

2. Calculations and formulas

IV. Mark Holding Attachments and Methods

A. Between Centers

B. Chucks

1. Jacobs

2. 3-jaw Universal

3. 4-jaw Independent

C. Collets

D. Faceplates

E. Steady and Hollow Rests

F. Mandrels

V. Basic Lathe Operations

A. Turning to Diameters

1. Rough turning

2. Finish turning

B. Facing to Lengths

C. Turning to a Shoulder

D. Grooving and Necking Operations

E. Parting Operations

F. Drilling and Boring

G. Reaming

H. Knurling

I. Filing and Polishing

J. Grinding

K. Taper Turning and Methods

1. Internal

2. External

L. Thread Cutting

1. Internal

2. External

VI. Industrial Lathe Applications

A. Tool Room Lathes

B. Geared Head Lathe

C. Combination Lathe/Miller

D. Turret Lathes

E. Screw Machines

F. Vertical Boring Machines

VII. Production Applications

A. NC Lathes

B. CNC Lathes

COMPUTER NUMERICALLY CONTROLLED LATHE

The Computer Numerically Controlled (CNC) Lathe, like other lathes, can cut in both the X (cross slide) and Z (longitudinal) axis. Each axis has its own step motor to control the feed rate. By using the two feed motors simultaneously, tapered, angular and circular cuts can be made.

Usually a CNC lathe can be programmed in either the absolute or incremental system. The absolute system takes all the figures from the "0" position. If, for some reason, it is necessary to change a figure, all the other figures remain unchanged. For this reason, most people choose to program in the absolute system. When a point or figure must be changed in the incremental system, all the following points must be changed. This causes a problem, especially if the program is long.

There are two basic types of keyboard used for programming information into the computer. One is the full typewriter keyboard. the other has ten digit keys (0-9) and a few additional keys. This is the type used on most industrial CNC machines. Typing skills are not necessary with this keyboard.

Basic machining is necessary before any CNC programming is possible. You must be able to plan the operations needed to make a part on an engine lathe before you can program a CNC lathe to make the same part.

CURRICULUM

COMPUTER NUMERICALLY CONTROLLED LATHE

I. Comparison of Traditional with CNC Machine

A. Structural Characteristics

1. D.C. stepper motor drive

2. Individual drives

3. Ball screw

4. Measuring system

B. Control Panel (keyboard)

C. Microprocessor Control

1. Manual input of data

2. External input

II. Modes of Control

A. Point to Point

B. Straight Line

C. Contouring

III. Machine Axes

A. X-Axis

B. Z-Axis

IV. Programming Methods

- A. Absolute System
- B. Incremental System
- C. Locating Zero Point
- D. Theory on Programming

V. Program Codes

- A. G Codes
  1. Preparatory
  2. Traverse
  3. Cycles
  4. Feeds
- B. F Codes
- C. X + Z Coordinates
- D. Tool Selection Codes

VI. Computer Operation

- A. Loading and Saving Programs
- B. Data Input
- C. Editing
- D. Error Messages

VII. Programming

- A. Machine Functions
- B. Roughing Cuts
- C. Finishing Cuts
- D. Contours and Shapes

VIII. Program Entry

A. Input of Data

B. Program Number

C. Input of Program

1. Keyboard visual display unit (VDU)

2. Tape

3. Memory

D. Program Run Through (simulation)

IX. Application

A. Secure Material

B. Set-up Tooling

C. Establish Zero Points

D. Run Program

E. Complete Part

F. Inspection

X. Industrial Applications and Production

CURRICULUM

INTRODUCTION TO THE MILLING MACHINE

I. Types of Milling Machines
   - A. Horizontal Milling Machine (Plain Milling Machine)
   - B. Vertical Spindle Milling Machine
   - C. Universal Milling Machine

II. Work Table Movements
   - A. Vertical
   - B. Cross Travel
   - C. Longitudinal
   - D. Angular (rotary) or (swivel)

III. Machine Movement Controls
   - A. Manual
   - B. Semiautomatic
   - C. Automatic (NC or CNC)

IV. Cutting Speed Controls

V. Milling Cutters
   - A. Milling Operations
     1. Face milling
     2. Peripheral milling
   - B. Types of Cutters
     1. Solid cutters
     2. Inserted tooth cutters

C. Cutter Classification

1. Arbor cutters
2. Shank cutters
3. Facing cutters

D. Cutter Material

1. H.S.S.
2. Carbides

E. Kinds of Milling Cutters

1. Plain milling cutter
2. Side milling cutter
3. Angle cutters
4. Metal slitting saws
5. End mills
6. Formed milling cutters
7. Specialty cutters

VI. Cutting Methods

A. Conventional (up milling)

B. Climb (down milling)

VII. Driving and Holding Cutters

A. Arbors

B. Tapers

C. Adapters

D. Collets and Sleeves

E. Shanks

F. Draw Bar

VIII. Cutting Speeds and Feed Rates

IX. Cutting Fluids

X. Work Holding Attachments

- A. Vises
- B. Magnetic Chuck
- C. Rotary Table
- D. Index Table
- E. Dividing Head
- F. Chucks

XI. Milling Operations

- A. Mount Work
- B. Squaring Stock
- C. Face Milling
- D. Side Milling
- E. Milling a Slot
- F. Slitting and Slotting
- G. Drilling and Boring
- H. Gear Cutting
- I. Machining Angular Surfaces

XII. Milling Machine Care and Safety

XIII. Production Applications

- A. NC Milling Machines
- B. CNC Milling Machines
- C. Machining Centers

COMPUTER NUMERICALLY CONTROLLED (CNC) MILLING

The CNC milling machine is similar to other milling machines. Cuts can be made in any of the three axes. The X axis is in and out, the Z axis is left and right and Y axis is up and down. Each of the three directions is controlled by its own step motor which is controlled by the computer.

Basic milling machine knowledge is necessary before any CNC programming is possible. The operational procedure is the same on the CNC machine as it is on a conventional miller.

The milling machine can be programmed in either incremental or absolute positioning. Absolute programming takes all the figures from a "0" position. If for some reason it is necessary to change one figure, all the other figures remain unchanged. For this reason, most people choose to program in the absolute mode. When a figure in the incremental system has to be changed, all the following positions have to reprogrammed.

A simple keyboard as used in industry is desirable. It has ten digits, 0-9, and a few other keys to program the machine. With this type keyboard typing skills are not necessary.

CURRICULUM

COMPUTER NUMERICALLY CONTROLLED MILLING

I. Comparison of Traditional with C.N.C. Machines

   A. Structural Characteristics

      1. D.C. Stopper motor drive

      2. Individual drives

      3. Ball screw

      4. Measuring system

      5. Control panel and keyboard

      6. Microprocessor - control

         a. Manual input of data

         b. External input of data (tape, memory, etc.)

II. Modes of Control

   A. Point to Point

   B. Straight Cut (paraxial)

   C. Contouring (linear and circular)

III. Machine Axes

   A. Horizontal Spindle Machine

      1. X-axis

      2. Y-axis

      3. 2 axes - tool

      4. Coordinate system

B. Vertical Spindle Machine

1. X-axis

2. Y-axis

3. Z-axis

4. Coordinate system

IV. Locating Workpiece Zero Point

A. Vertical Spindle

B. Horizontal Spindle

V. Zero Point Shift

VI. Point Definition Related to Zero Point

VII. Absolute Dimensions

VIII. Incremental Dimensions

IX. Tool Compensation

X. Tool Change

XI. Program Preparation

A. Tool Selection

B. Tool Compensation

C. Data Summary

1. Speed

2. Feed rate

3. Tool rotation

D. Tool Movement

1. G - code movements

2. Cycle code movements

XII. Program Entry

- A. Input of Tool Data
- B. Program Number
- C. Input of Program
  1. Keyboard and visual display unit (VDU)
  2. Tape
  3. Memory
- D. Program Run Through (simulation)

XIII. Application

- A. Secure Material
- B. Acquire Tooling
- C. Establish Zero Points
- D. Run Program
- E. Complete Part
- F. Inspection

XIV. Industrial Applications and Production

"CAM"

Increased productivity has always been the goal of the manufacturing industry. With the advent of programmable automation (PA), great strides have been made toward this goal. NC machining, with the use of punched cards and tapes, was the beginning, quickly followed by CNC machining. The computer has long been used in the administrative offices of manufacturers, but its use in the technological aspects of the industry is relatively new. CNC machinery has brought about the development of the machinery center. Machinery centers are machines capable of performing several different operations in the same set-up. The development of NC and CNC has opened the door to computerized aided manufacturing (CAM).

CAM is a combination of computerized machining and robotics. A robot is basically a numerically controlled arm and hand which has the ability to pick up and move a variety of different shaped parts. Rapid changes are being made in robot abilities. They can "see" different shapes, assemble parts and self-check their own accuracy. There are two basic types of robot. The "hard-wired" type can only perform a specific task. The computer programmable robot moves through a prescribed set of steps. The computer program can be changed as needed.

Today many robots are being used in industry. Some of the tasks robots perform are unsuitable or dangerous for humans, but other common tasks such as welding and painting on assembly lines are also being done by robots.

It is difficult to consider CAM as a single system. It must be considered in its place within the complete PA system. Most of the PA system is included in the CAD/CAM (computer aided design/computer aided manufacturing) system.

The CAD/CAM system, through the interfacing of computers, makes possible the design of parts, the programming of CNC equipment and the programming of robots from a central location. Thus, with current technology, it is possible to have a plant in which material can be moved from machine to machine by robots, inspected and completely finished without human assistance. Such systems are being used in industry today but on a very small scale. The Office of Technology Assessment (OTA) believes it will be at least 10 to 15 years before the complete technology is used to operate factories without production workers.

There are indications that PA (programmable automation) will cause the following long-term trends in the labor force. Demand will rise for engineers, computer scientists, technicians, mechanics, repairers and installers. Upper level managers, technical sales and service personnel will also be in demand. Opportunities will diminish for drafters, craftworkers, operatives and laborers. The least-skilled, those doing the most routine work, will be especially effected. There will be less need for lower and middle management personnel. These shifts in demand will not significantly affect the national unemployment figures, although they could cause regional unemployment.

NC and CNC equipment are being introduced into the school system. With the advent of PA this trend must continue. The Office of Technology Assessment believes the United States instructional system may not be able to accommodate the potential demand for PA related skills. Basic skills, such as reading, science and math, must be improved as a prerequisite for the training of PA related instruction.

METAL WORKING SAFETY GUIDE

Working safely is the first essential students should learn even before they are taught how to operate any of the machine tools or use hand tools in your shop. The student can easily learn to work safely, and it is just as easy to learn the safe way of doing things as it is to learn the unsafe way.

Safety is an attitude; that is, it is a frame of mind. If the students attitudes towards safety are good, they will accept the idea that safe working habits are the ones to learn and practice for the rest of their lives. Most important, students must make up their minds that working with other people in the shop is their business. Keeping themselves, as well as those working with them, free from accidents is also part of their attitude towards safety.

I. Metal Machinery General Safety Requirements

A. Always be sure you have the instructor's approval to operate a machine.

B. Wear appropriate clothing. Remove coats or jackets, loose jewelry, tuck in loose clothing and roll up loose sleeves above the elbows. Always wear appropriate eye protection.

C. You must be wide awake and alert. Never operate a machine when you are tired or ill.

D. Think through the operation before performing it. Know what you are doing and what the machine will do.

E. Make all the necessary adjustments before turning on the machine. Some adjustments on certain machines will require the instructor's approval.

F. Never remove or adjust a safety guard without the instructor's permission.

G. Keep the machine and working surfaces clear of tools, stock, and project materials. Also keep the floor free of scraps and excessive litter.

H. Allow the machine to reach its full operating speed before starting to feed the work. Always set the machine for the correct cutting speeds.

I. Feed the work carefully and only as fast as the machine will cut it easily.

J. Maintain the MARGIN OF SAFETY specified for the machine. This is the minimum distance your hands should ever come to the cutting tool while it is in operation.

K. If a machine cutter is dull, the machine out of adjustment, or in some way not working properly, shut off the power immediately, and inform your instructor.

L. You are the one to control the operation. Start and stop the machine yourself. If someone is helping you, be sure they understand this and know what they are expected to do and how to do it.

M. Do not allow your attention to be distracted while operating a machine. Also, be certain that you do not distract the attention of other machine operators.

N. Stay clear of a machine that is being operated by another student. See that other students are not in your way while you are operating a machine.

O. When you have completed an operation on a machine, shut off the power and wait until it stops before leaving the machine or setting up another cut. Never leave a machine running unattended.

P. Do not play or tamper with machines in the shop. Each tool or machine was designed for a specific operation, and should not be used as a toy.

Q. Do not crowd around or wait in line to use a machine. Ask the present operator to inform you at your work station when he or she has finished. Common standards of courtesy may slow you down a little, but they will make the shop a more pleasant and safer place to work.

II. Machine Safety Rules

A. Engine Lathe

1. Before turning on the power, check to see that the tailstock, tool holder, and job are properly clamped and proper clearance is maintained.

2. Use hand power only when putting on or removing chuck or faceplate. Do not use the power that operates the lathe.
3. When assembling or removing the chuck, place a board on ways to prevent damage to machine and possibly to operator in case the chuck falls. Have firm grip on chuck as it nears the end of threads.
4. Do not leave chuck wrench or any other tool in the chuck. If machine is turned on, wrench may fly out and injure the operator or any other person.
5. Do not use wrench on revolving work or parts.
6. Never try to measure work or feel the edge, or adjust a cutting tool when lathe is running.
7. Do not take heavy cuts on long slender work. Doing so may cause the job to fly out of the machine.
8. When filing, be sure that the tang of the file is fitted with a proper handle. Stand to one side so that, if the file is forced upward, it will go past the body rather than against it.
9. Do not shift or change gears while the lathe is running.
10. Stand erect with your weight equally distributed on both feet.

B. Milling Machine

1. Make sure that the cutter and arbor are secure and that the cutter and arbor support clear the work.

2. Use only cutters that are correctly ground and in good condition.
3. To avoid striking hands on the cutter while setting up, move table with work as far away from cutter as possible.
4. When using cutters in a milling machine, do not take an excessively heavy cut or feed. Such a feed or cut could break the cutter and injure the operator.
5. Do not try either to tighten or take off arbor nut by applying power to machine. Make sure motor is OFF.
6. Check speeds and feeds, and feed work against direction in which cutter is rotating.
7. Keep hands away from work when machining.
8. Never reach over a revolving cutter, especially the side of cutter which cuts into the work.
9. Use a brush not the hands to remove chips, and always turn off cutter before trying to remove chips.

GLOSSARY

ABSOLUTE ACCURACY: Accuracy as measured from a reference which must be specified.

ABSOLUTE READOUT: A display of the true slide position as derived from the position commands within the control system.

ABSOLUTE SYSTEM: A numerical control system in which all positional dimensions, both input and feedback, are given with respect to a common datum point. The alternative is the incremental system.

ACCURACY: Measured by the difference between the actual position of the machine slide and the position demanded. Conformity of an indicated value to a true value, i.e., an actual or an accepted standard value. The accuracy of a control system is expressed as the deviation usually in the steady state or a sampled instants.

ALPHANUMERIC CODING: A system in which the characters are letters A through Z and numbers 0 through 9.

ARC CLOCKWISE: An arc generated by the coordinated motion of two axes, in which curvature of the tool path with respect to the workpiece is clockwise, when viewing the plane of motion from the positive direction of the perpendicular axis.

ARC COUNTERCLOCKWISE: An arc generated by the coordinated motion of two axes, in which curvature of the tool path with respect to the workpiece is counterclockwise, when viewing the plane of motion from the positive direction of the perpendicular axis.

ASCII: (American Standard Code for Information Interchange) A data transmission code which has been established as an American standard by the American Standards Association. It is a code in which seven bits are used to represent each character. Formerly USASCII.

AUTOMATION: The implementation of processes by automatic means. The investigation, design, development, and application of methods to render a process automatic, self-moving, or self-controlling.

AXIS: A principle direction along which the relative movements of the tool or workpiece occur. There are usually three linear axes, mutually at right angles, designated as X, Y, and Z.

BINARY CODE: Based on binary numbers which are expressed as either 1 or 0, true or false, on or off.

BUG: A mistake or malfunction; an integrated circuit (slang).

BYTE: A sequence of adjacent binary digits usually operated on as a unit and shorter than a computer word.

CAD: (Computer Aided Manufacturing) The use of computers to assist in phases of manufacturing.

CANCEL: A command which will discontinue any canned cycles or sequence commands.

CANNED CYCLE: A preset sequence of events initiated by a single command. For example code G84 will perform tap cycle by NC.

CARTESIAN COORDINATES: A means whereby the position of a point can be defined with reference to a set of axes at right angles to each other.

CHIP: A single piece of silicon cut from a slice by scribing and breaking. It can contain one or more circuits but is packaged as a unit.

CIRCULAR INTERPOLATION: Capability of generating up to 360 degrees of arc using only one block of information as defined by EIA. A mode of contouring control which uses the information contained in a single block to produce an arc or a circle.

CLOSED LOOP SYSTEM: A system in which the output or some result of the output, is measured and fed back for comparison with the input.

CNC: Computer Numerical Control.

COMMAND: A signal or series of signals initiating one step in the execution of a program.

COORDINATE DIMENSIONING: A system of dimensioning based on a common staring point.

CUTTER DIAMETER COMPENSATION: A system in which the programmed path may be altered to allow for the difference between actual and programmed cutter diameter.

CUTTER OFFSET: The distance from the part surface to the axial center of a cutter.

CUTTER PATH: The path defined by the center of a cutter.

CYCLE: A sequence of operations that is repeated regularly. The time it takes for one such sequence to occur.

DATA: A representation of information in the form of words, symbols, numbers, letters, characters, digits, etc.

DIGIT: A character in any numbering system.

DISPLAY: A visual representation of data.

EDIT: To modify the form of data.

FEED: The programmed or manually established rate of movement of the cutting tool into the workpiece for the required machining operation.

FLOATING ZERO: A characteristic of a machine control unit permitting the zero reference point on an axis to be established readily at any point in the travel.

G CODE: A word addressed by the letter G and followed by number code defining preparatory functions or cycle types in a numerical control system.

HARD COPY: A readable form of data output on paper.

INCREMENTAL DIMENSIONING: The method of expressing a dimension with respect to the preceding point in a sequence of points.

INCREMENTAL SYSTEM: A control system in which each coordinate or positional dimension, both input and feedback is taken from the last position rather than from a common datum point, as in the absolute system.

INPUT: Transfer of external information into the control system.

INTERPOLATION: The insertion of intermediate information based on an assumed order or computation. A function of a control whereby data points are generated between given coordinate positions.

ISO: International Organization for Standardization.

LINEAR INTERPOLATION: A function of a control whereby data points are generated between given coordinated positions to allow simultaneous movement of two or more axes of motion in a linear path.

MACHINING CENTER: Machine tools, usually numerically controlled, capable of automatically drilling, reaming, tapping, milling, and boring multiple faces of a part. They are often equipped with a system of automatically changing cutting tools.

MEMORY: An organized collection of storage elements, disc, drum, ferrit cores, into which a unit of information consisting of a binary digit can be stored and from which it can later be retrieved.

NC: (Numerical Control) the technique of controlling a machine or process by using command instructions in coded numerical form.

PERFORATED TAPE: A tape on which a pattern of holes or cuts is used to represent data.

POINT TO POINT CONTROL SYSTEM: A numerical control system in which controlled motion is required only to reach a given end point, with no path control during the transition from one end point to the next.

PREPARATORY FUNCTION: A NC command on the input tape changing the mode of operation of the control.

PROGRAM: A sequence of steps to be executed by a control or a computer to perform a given function.

QUADRANT: Any of the four parts into which a plane is divided by rectangular coordinate axes in that plane.

RESET: To return a register or storage location to zero or to a specified initial condition.

SOFTWARE: Instructional literature and computer programs used to aid in part programming, operating, and maintaining the machining center.

TAPE: A magnetic or perforated paper medium for storing information.

TOOL FUNCTION: A tape command identifying a tool and calling for its selection. The address is normally a T word.

TOOL LENGTH COMPENSATION: A manual input, by means of selector switches, to eliminate the need for preset tooling; allows the programmer to program all tools as if they are of equal length.

TOOL OFFSET: A correction for tool position parallel to a controlled axis. The ability to reset tool position manually to compensate for tool wear, finish cuts, and tool exchange.

X AXIS: Axis of motion that is always horizontal and parallel to the workholding surface.

Y AXIS: Axis of motion that is perpendicular to both the X and Z axes.

Z AXIS: Axis of motion that is always parallel to the principal spindle of the machine.

ZERO OFFSET: A characteristic of a numerical machine tool control permitting the zero point on an axis to be shifted readily over a specified range. The control retains information on the location of the permanent zero.

SUGGESTED TEXT & REFERENCE BOOKS

The following is a list of suggested text and reference books that has been compiled by this committee. We feel that this list is representative of the books available in the subject area, however, you may find others that fit your program and methods of teaching.

METALS MACHINING

Oberg and Jones. Machinery Handbook. Industrial Press.

McCarthy and Repp. Machine Tool Technology. McKnight.

Walker. Machining Fundamentals. Goodheart-Willcox.

Feirer. Machine Tool Metalworking. McGraw-Hill.

Burghardt. Machine Tool Operations. McGraw-Hill.

Iascoe. Machine Shop Operations and Setups. American Tool Society.

Johnson. General Industrial Machine Shop. Bennett.

South Bend Lathe. How to Run a Lathe. South Bend Lathe.

Delmar. "Machine Shop Series". A. Bench Work; B. Drill Press Work; C. Heat Treatment of Metals.

Walker. Modern Metalworking. Goodheart-Willcox.

L.S. Starrett. The Starrett Book for Student Machinists. L.S. Starrett Co.

Johnson. Technical Metals. Bennett.

Feirer. General Metals. McGraw-Hill.

White, Neely, Kibbe, and Meyer. Machine Tools & Machining Practices. Wiley.

McGrath and Ludwig. Metalwork Technology & Practice. McKnight.

Chaplin. Metal Manufacturing Technology. McKnight.

Olivo. Fundamentals of Machine Technology. Breton.

Hill and Dygdon. Technical Drawing. MacMillan.

Nelson. Basic Drafting for Design. South-Western.

Jenson and Hines. Interpreting Engineering Drawings. Delmar.

Gardner. "Modern Machine Shop", (NC & CAM Guide Book).

Keller. "Maho Machines" (Instructions and Worksheets). Wuppertal.

Knox. "CAD/CAM Systems".

Office of Technology Assessment. "Computerized Manufacturing Automation".

Luggen. Fundamentals of Numerical Control. Delmar.